

DIOCUS LYCENCHELUS NEW SPECIES (COPEPODA:
CHONDRACANTHIDAE) PARASITIC ON THE EELPOUT
LYCENCHELYS VERRILLII (ZOARCIDAE) FROM THE
HATTERAS SLOPE OF THE NORTHWEST ATLANTIC OCEAN

William E. Hogans and Kenneth J. Sulak

ABSTRACT

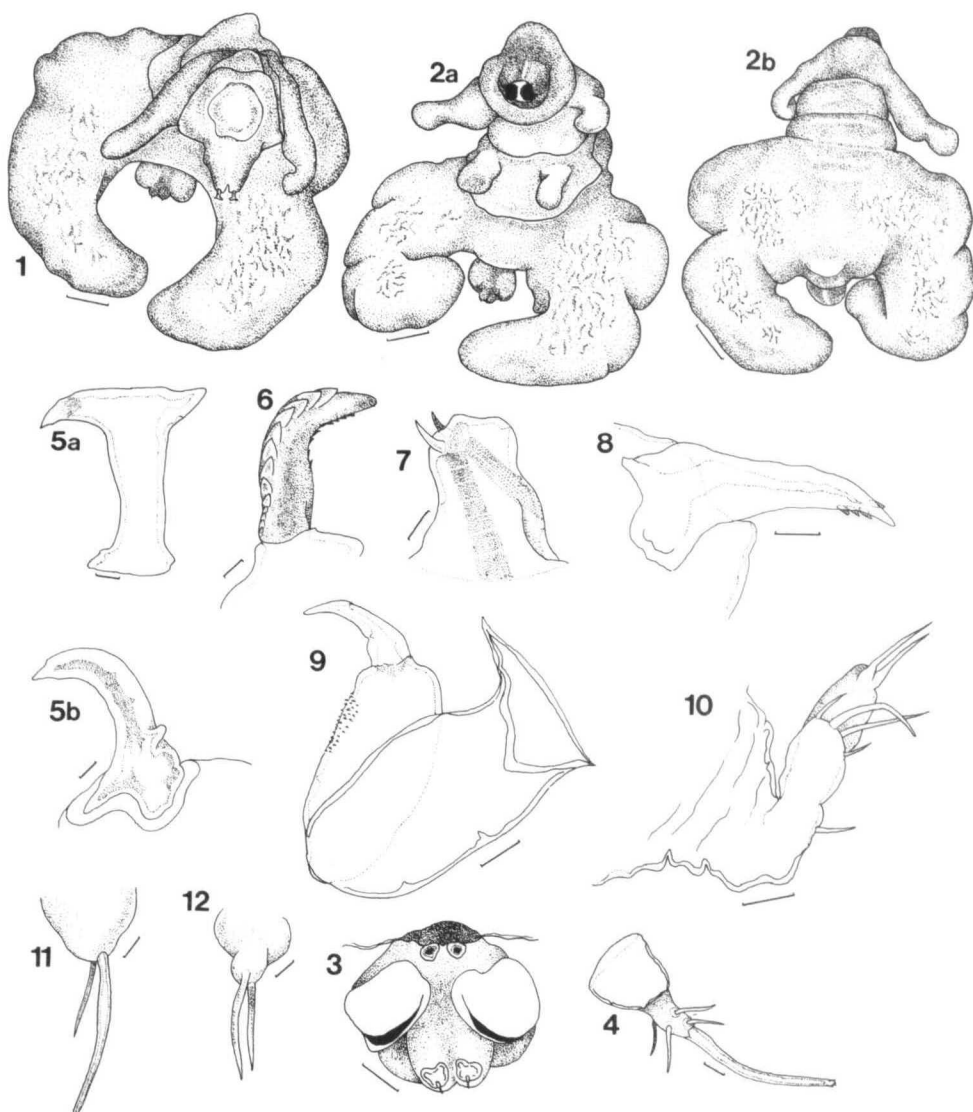
A new species of parasitic copepod, *Diocus lycenchelus*, is described from the demersal zoarcid fish *Lycenchelys verrillii* caught off Cape Hatteras, U.S.A. The new species differs from its congeners in the shape of the cephalothorax, trunk (ventrolateral processes), fine structure of appendages (mandible, second maxilla, first thoracic leg) and site of infection (the nares). A comparison of the morphology of *D. lycenchelus* n. sp. is made with that of the other four recognized species of *Diocus* (*D. frigidus*, *D. gobinus*, *D. semilunaris*, *D. sadoensis*).

Members of the copepod genus *Diocus* Kroyer, 1863 are parasites of epibenthic marine fishes in boreal-arctic waters. Currently, four species are recognized as valid. *Diocus gobinus* (Muller, 1777), the type species, is found only on the sculpin *Gymnacanthus tricuspis* (cf. Walters, 1953) from the North Sea and off west Greenland. *Diocus frigidus* (Hansen, 1923) has been found only on the eelpouts *Lycodes furneri* in the North Pacific off Alaska (Walters, 1953) and on *Lycodes frigidus* in the Norwegian Sea east of Iceland (Hansen, 1923). *Diocus semilunaris* (Kabata and Gusev, 1966), senior synonym of *Parapharodes semilunaris* (cf. Ho, 1970) has been found on the eelpout, *Lycodes diapterus*, off the coast of Kamchatka in the West Bering Sea. *Diocus sadoensis* (Shiino, 1960) was described from the blennioid fish *Lumpenus macrops* collected in the northern Sea of Japan. All four of these species were recovered from the gill chambers of their respective hosts. Generally, *Diocus* resembles its congeners within the Chondracanthidae by possessing a large pregenital trunk (Hogans and Benz, 1990) with lobate processes and characteristically uniform oral appendages. The salient features of *Diocus* are the horseshoe-shaped trunk and the second antenna which is transverse distally, exhibiting a T-shaped structure; no other chondracanthid is characterized by a second antenna of this shape.

In this paper we describe a fifth and new species of *Diocus*, *D. lycenchelus* n. sp. from a cryptic site of infection, the nasal cavity, on Verrill's wolf eelpout, *Lycenchelys verrillii*, from the Hatteras slope of the northwestern Atlantic Ocean.

MATERIALS AND METHODS

Specimens of the new species were recovered from the nasal cavities of the demersal eelpout *Lycenchelys verrillii* collected north of Cape Hatteras on the continental slope at 484-722 m depth in July 1991 during two dives (Mission UNCW 9112) of the submersible DSRV JOHNSON-SEA-LINK. The parasites were discovered during routine identification and cataloging of the hosts, which were initially fixed in 10% formalin and later transferred to 50% isopropyl alcohol. Two adult females and one juvenile female, each with an attached male were removed from the nasal cavities and used for microscopic examination. Two other adult females (potentially with attached males) were left in situ in the nasal cavities. Specimens on which description of appendages was based were dissected in 85% lactic acid, stained with lignin pink and examined under a compound microscope. Figures were drawn with the aid of a drawing tube. Terminology of appendages follows that of Kabata and Gusev (1966) and Kabata (1979).



Figures 1–12: 1—*Diocus lycenchelus*, adult female, holotype, NMC 1991–2350, anterior (scale bar = 0.5 mm). 2—*Diocus lycenchelus*, adult female, paratype, NMC 1991–2351. a. ventral, second antenna removed. b. same, dorsal (scale bars = 0.5 mm). 3—Genito-abdominal tagma, ventral (scale bar = 0.5 mm). 4—Uropod, ventral (scale bar = 0.006 mm). 5—Second antenna. a. from adult, ventral. b. from juvenile, ventral (scale bar = 0.018 mm). 6—Mandible, dorsal (scale bar = 0.006 mm). 7—First maxilla, ventral (scale bar = 0.006 mm). 8—Claw of second maxilla, dorsal (scale bar = 0.005 mm). 9—Maxilliped, ventral (scale bar = 0.018 mm). 10—First thoracic leg, ventral (scale bar = 0.018 mm). 11—Second thoracic leg, ventral (scale bar = 0.006 mm). 12—Third thoracic leg, ventral (scale bar = 0.006 mm).

***Diocus lycenchelus* new species**

Figures 1–21

Hosts.—Zoarcidae, *Lycenchelys verrillii* (Goode and Bean, 1977), 122–137 mm TL, Atlantic Reference Centre ARC9111440, ARC9111441, ARC9111445, ARC9111465.

Locality.—Hatteras slope, northwestern Atlantic Ocean: DSRV JOHNSON-SEA-LINK Cruise UNCW 9112, Dives 3068, 3070; 35°30'31"N, 74°47'78"W: 484–722 m depth.

Site of Infection.—Nasal cavities.

Specimens.—Holotype—adult female (with attached male), National Museum of Canada, Ottawa, NMC 1991–2350. Paratype—adult female, NMC 1991–2351. Additional specimen—adult female in situ in host fish, ARC 9111441.

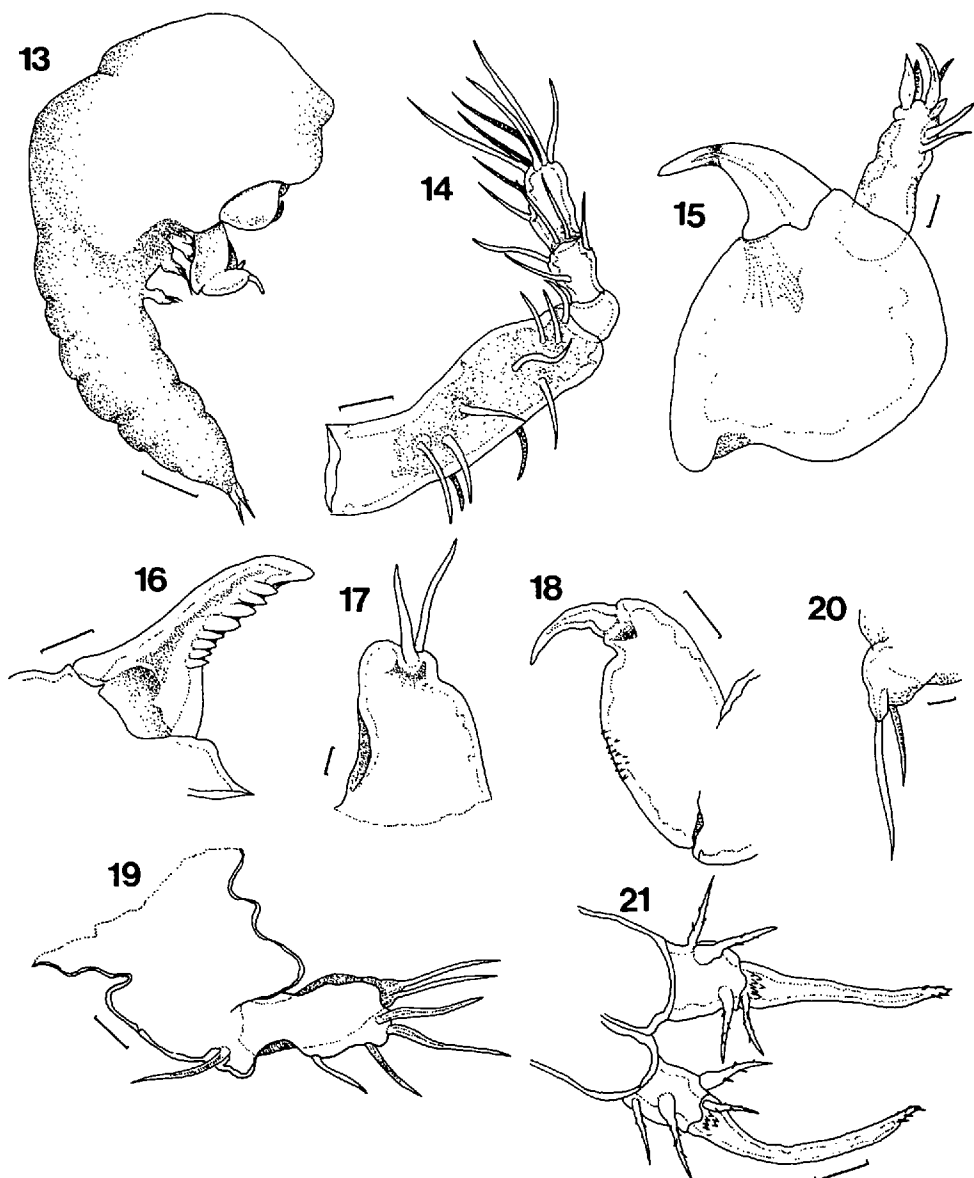
Etymology.—The species name after the host genus *Lycenchelys*.

Description.—FEMALE (Figs. 1 to 12). Cephalosome longer than wide, roughly cone-shaped, dorsal margin much wider than ventral. Anterior surface with large, rounded medial swelling. Dorsal shield not apparent. Trunk much more massive than cephalosome, about as wide as long. First thoracic segment with minor constriction separating cephalosome from trunk; and two large digitiform ventrolateral processes. Second thoracic segment about size of first, unarmed. Third thoracic segment twice size of first and second, provided with two short, globular ventrolateral processes. Fourth and fifth (and sixth?) thoracic segments fused, forming a massive horseshoe-shaped posterior trunk. Genito-abdominal tagma (Fig. 3) with large, semi-spherical genital segment with distinct oviduct orifices and ventrolateral lacunae. Abdomen on ventral posterior surface, indented at base, with round apices. Uropods (caudal laminae of Kabata and Gusev, 1966) (Fig. 4) with four spiniform setae on anterior portion; terminal portion in the form of large, stiff seta armed with several hairs (setules?) at tip. Eggs multiseriate. Total length (from top of cephalosome to tip of trunk—as measured on specimen in Fig. 2a) 5 mm.

First antenna very small, located just anterior to base of second. Apparently four-segmented. Fifth segment three times length of second. Third and fourth segments same length as second. All segments cylindrical. Apical armature indistinct. Second antenna (Fig. 5a, b) T-shaped (Fig. 5a) in adult female; in the form of recurved hook (Fig 5b) with blunt process near base (destined to form opposite end of transverse bar?) in juvenile female. Mandible (Fig. 6) with 25–30 serrations on ventral surface; dorsal surface with 13 denticles, small near base, largest near tip. First maxilla (Fig. 7) sub-quadrangular, armed with two spiniform setae on ventromedial surface. Second maxilla with sub-quadrangular basal segment; claw (Fig. 8) straight with slightly upturned tip. Maxilliped (Fig. 9) with unarmed lacertus, brachium with patch of fine denticles on inner margin: claw unarmed, small indentation on inner surface at mid-length. First thoracic leg (Fig. 10) with apparently one-segmented sympod; exopod with four terminal setae, and one seta on indistinct penultimate segment; endopod with two setae on gibber-like base. Second thoracic leg (Fig. 11) with globular base, armed with one large, stout seta and one smaller, slender seta. Third thoracic leg (Fig. 12) reduced, with broad basal segment, globular second(?) segment; armed with two setae of similar lengths.

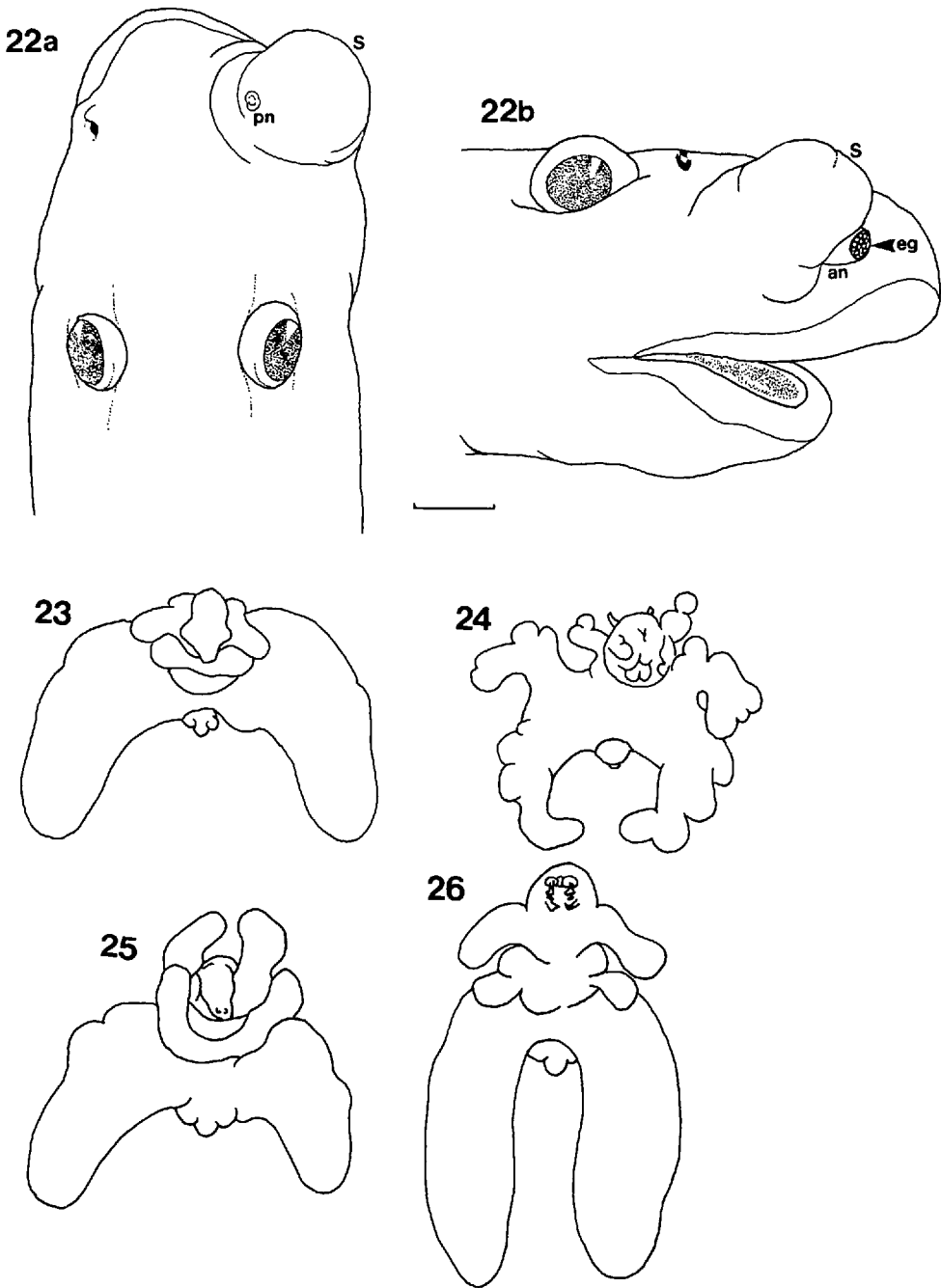
MALE (Figs. 13 to 21). Cephalosome subcircular, inflated, with indistinct dorsal carapace. Posterior half of body pseudosegmented, tapering posteriorly. Uropods (Fig. 21) prominent, armed on base with four setae: basal setae each provided with several setules. Terminal portion in the form of large, elongate setae armed at base on ventral surface with small patch of denticles and at tips with several small setules. Total length about 0.7 mm.

First antenna (Fig. 14) four-segmented. Basal segment comprising two-thirds length of entire appendage, armed with at least ten slender setae. Second, third



Figures 13–21: 13—*diocus lycenchelus*, male, lateral (scale bar = 0.10 mm). 14—First antenna, ventral (scale bar = 0.01 mm). 16—Mandible, dorsal (scale bar = 0.006 mm). 17—First maxilla, ventral (scale bar = 0.025 mm). 18—Maxilliped, ventral (scale bar = 0.006 mm). 19—First thoracic leg, lateral (scale bar = 0.025). 20—Second thoracic leg, lateral (scale bar = 0.006 mm). 21—Uropods, ventral (scale bar = 0.01 mm).

and fourth segments forming geniculation from first. Segment two unarmed. Third segment with three setae. Terminal segment with four non-apical setae and six slender setae at tip. Second antenna (Fig. 15) biramous; endopod with large, stout hook at apex; exopod (?) with apical armature of seven setae of various shapes. Mandible (Fig. 16) similar to that of female except with eight dorsal denticles; number of ventral serrations not determined. First maxilla (Fig. 17) with two elongate terminal setae. Second maxilla resembling that characteristic of female.



Figures 22–26: 22—Head of infected *Lycenchelys verrillii* (ARC9111441, 137 mm TL) with *D. lycenchelus* n. sp. a. dorsal view b. lateral view. (an = anterior nostril; eg = eggs of *D. lycenchelus*; pn = posterior nostril; S = swelling caused by parasite. scale bar = 10 mm). 23—Outline of body, *D. frigidus*, ventral (after Walters, 1953). 24—Outline of body, *D. gobinus*, ventral (after Yamaguti, 1963). 25—Outline of body, *D. sadoensis*, ventral (after Shiino, 1960). 26—Outline of body, *D. semilunaris*, ventral (after Kabata and Gusev, 1966).

Table 1. Comparison of appendage structure of adult females among species of *Diocus*. (NA = Condition cannot be specified, no information available)

Species	First antenna (No. segments)	Mandible (No. denticles)	Second maxilla (auxillary spine)	Maxilliped (denticles)	Caudal lamina (No. basal setae)
<i>D. frigidus</i> *	3	NA	NA	NA	NA
<i>D. gobinus</i> †	3	NA	NA	NA	0
<i>D. lycenchelus</i>	4	13	no	yes	4
<i>D. sadoensis</i> ‡	6	NA	yes	yes	2
<i>D. semilunaris</i> §	NA	15	yes	no	3

* from Walters (1953).

† from Hansen (1923).

‡ from Shiino (1960).

§ from Kabata and Gusev (1966).

Maxilliped (Fig. 18) like that of female, with fewer and larger denticles on brachium inner margin. Thoracic leg 1 (Fig. 19), 2 (Fig. 20), and 3 with structures comparable to those of adult female.

DISCUSSION

In each of the host fish, only one specimen of *D. lycenchelus* was found. However, two specimens, an adult female and a much smaller juvenile female, were found in the same nostril of a third host. All of the parasites found were recovered from the right nasal cavity. Infection of the nostril by *D. lycenchelus* caused a large swelling under the skin surrounding the parasite (Fig. 22a, b). This probably seriously impaired nostril function. When dissected from the host each specimen was oriented with the tip of the cephalothorax directed toward the posterior part of the nasal cavity with the second antennae firmly embedded to their bases in the epithelium. The parasite utilizes the anterior nostril as a duct for release of eggs (Fig. 22b).

The new species is placed in the genus *Diocus* based on the structure of the second antenna (T-shaped) and the morphology of the posterior trunk (horseshoe-shaped). There are important behavioral and morphological differences between *D. lycenchelus* and the other four known species as follows: 1) the new species is a parasite of the nares; the other four species are found only in the gill cavities; 2) the female of the new species possesses a cone-shaped cephalosome; *D. gobinus*, *D. semilunaris*, and *D. sadoensis* and *D. frigidus* variously exhibit globular, semi-spherical, subrectangular, and short, subrectangular cephalosomes, respectively. Furthermore, the general shape and the ventrolateral processes of the trunk of females (see Figs. 23–26) are different in each of the five species of *Diocus*. *Diocus lycenchelus* has retained a rather complex first thoracic leg as compared to that described by Kabata and Gusev (1966) for *D. semilunaris* (simple, with two elongate, digitiform processes), and for those figured for *D. frigidus* (cf. Walters, 1953) and *D. sadoensis* (Shiino, 1960). However, these last two descriptions and figures have limited usefulness for comparative purposes. Considering appendage structure of *Diocus*, it is instructive to compare that of *D. lycenchelus* with that of *D. semilunaris* as described in the comprehensive account of Kabata and Gusev (1966). The second antenna of both species is nearly identical. The mandible of *D. semilunaris* exhibits fewer serrations (20–25) than that of *D. lycenchelus* (25–30), but has more dorsal denticles (15) than the mandible of *D. lycenchelus* (13). The first maxilla is alike in both species. The claw of the second maxilla is similar in structure in both species, but the auxillary spine present near the base in *D. semilunaris* (and in *D. sadoensis*, Shiino, 1960) was not observed in *D. lycenchelus*. The maxilliped in *D. semilunaris* does not possess denticles on the brachium;

Table 2. Comparison of appendage structure of males among species of *Diocus*. (NA = no information available)

	First antenna (No. segments)	First maxilla (medial papilla)	Maxilliped (papilla on brachium)	Caudal lamina (No. basal setae)
<i>D. frigidus</i>	NA	NA	NA	NA
<i>D. gobinus</i>	NA	NA	NA	NA
<i>D. lycenchelus</i>	4	no	no	4
<i>D. sadoensis</i> *	NA	no	yes	2
<i>D. semilunaris</i> †	3	yes	no	3

* from Shiino (1960).

† from Kabata and Gusev (1966).

these occur on both male and female of the new species. Shiino (1960) described the male of *D. sadoensis* as having granulation (denticles?) on the inner margin of the maxilliped; he did not describe this feature from the female. Shiino (1960) also figured the brachium with a large process (papilla of Kabata and Gusev, 1966) on the anterior inner margin of both male and female—this process is absent in *D. semilunaris* and *D. lycenchelus*. A comparison of appendage structure of female *D. lycenchelus* and those recorded in the published descriptions of the other four species is presented in Table 1.

Kabata and Gusev (1966) considered the appendage structure of females uniform and unsuitable for differentiating species. We did observe uniformity in appendage morphology (for example, the maxilliped is nearly identical in all five species), but we also identified fine details (i.e., denticles on the branchium of the maxilliped, number of denticles on the mandible, presence or absence of an auxillary spine on the claw of the second maxilla) as characters suitable for differentiating species. Kabata and Gusev (1966) suggested the male as more likely to exhibit diagnostic features. Based on our examinations we concur that male morphology is useful for separating species of *Diocus* (Table 2), although we consider female appendage morphology to be equally suitable.

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ADDRESS: Atlantic Reference Centre, Huntsman Marine Science Centre, Brandy Cove, St. Andrews, New Brunswick, Canada E0G 2X0.